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ABSTRACT

In two experiments, researchers investigated whether the advantages of studying graphic organizers over outlines for learning text structure and transfer from a chapter-length text are restricted to study sequences that use delayed, rather than immediate, review. In the first of these studies, reported here, 89 undergraduates studied 1 of 3 sets of study materials, reviewed them immediately or 2 days later, and then were tested. Materials were the text, the text with graphic organizers, or the text plus a set of outlines. Results indicate that although graphic organizers facilitated learning text structure across both review occasions, they facilitated transfer of text knowledge only when review was delayed. The study also found evidence that students who delayed their review of graphic organizers used more effective study strategies. These findings are explained within the framework of the deactivation hypothesis (D. Krug, T. B. Davis, and J. A. Glover, 1990). (Contains 2 tables and 16 references.) (Author/SLD)

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The Interaction of Study Materials and Spaced Review on Transfer and Relational Learning

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Paper presented at the annual meeting of the American Educational Research Association, Chicago, Illinois, March 24-28, 1997.

(We are currently finishing a more complete paper that describes a second experiment. If you would like a copy of the completed paper, we could send you a copy in a few weeks.)

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Abstract

In two experiments, we investigated whether advantages of studying graphic organizers over outlines for learning text structure and transfer from a chapter-length text are restricted to study sequences that employ delayed, rather than immediate, review. Undergraduates studied one of three sets of study materials, reviewed them immediately or two days later, and then were tested. Results indicated that although graphic organizers facilitated learning text structure across both review occasions, they facilitated transfer of text knowledge only when review was delayed. We also found evidence that students who delayed their review of graphic organizers used more effective study strategies. These findings are explained within the framework of the deactivation hypothesis (Krug, Davis, & Glover, 1990).

Graphic organizers (GOs) are spatial displays of text information that can be provided to students as study aids (i.e., adjunct displays) that accompany text. GOs, like the one in Figure 1, communicate both vertical, hierarchical concept relations (e.g., neuroses is a type of abnormal behavior, is characterized by severe distress and lack of control over one's life, etc.), and also horizontal, coordinate concept relations (e.g., persons with neuroses are aware of their problems, whereas persons with psychoses and personality disorders are not). Although the outline displayed in Figure 2 contains the same information as the GO in Figure 1, recent evidence suggests that it is not as effective as the GO in communicating concept relations because it uses a linear, rather than spatial, format (Robinson & Kiewra, 1995; Robinson & Schraw, 1994). Winn (1990) has suggested that students may extract more information from a quick glance at a spatial display than they can from a longer viewing of a linear display. Unfortunately, most textbooks still contain outlines at the beginning of chapters, most students still take notes in an outline format, and most teachers write outlines of their lectures on the chalkboard. The present study was designed to investigate how GOs may be more effective than outlines as adjunct displays in environments similar to actual classroom learning; that is, where students read chapters of text and then review before being tested.

Graphic Organizers are better than Outlines

Several recent studies have examined the instructional advantage of providing GOs, rather than outlines, to students as adjunct displays. Robinson and Schraw (1994) had students read a short (200 words) text and then study either the same text, an outline, or a GO. Students who studied the GO learned more concept relations than those who studied only the text when tested immediately, even when the time to study was reduced to only one minute. When testing was delayed for 10 minutes, however, there were no advantages of studying GOs. Robinson and Schraw hypothesized that computing concept relations when studying outlines and texts requires more effort than when studying GOs. They concluded that the GO's advantage in computational efficiency (Larkin & Simon, 1987) may actually be detrimental to long-term (delayed) learning because too little effort is used during encoding.

Computational efficiency suggests that the facilitative advantage of GOs occurs during encoding, when concept relations are computed and then stored in memory as new propositions. Others have argued, however, that the facilitative advantage of spatial displays occurs during retrieval, when an additional spatial memory representation becomes available along with a verbal representation (e.g., Kulhavy, Lee, & Caterino, 1985). This possibility that the same information contained in different adjunct displays may be encoded in memory in different formats was examined in a study by Robinson, Katayama, and Fan (1996) who employed dual task methodology. Students studied one of four types of comprehension displays (a text, an outline, a GO, or a concept map), viewed either a spatial (set of dots) or verbal (set of numbers) memory display, and then were tested on comprehension of the first, and memory of the second display. When students viewed GOs or concept maps, recognition of the spatial display was inhibited, whereas

viewing texts or outlines did not interfere with memory of the spatial display. Robinson et al. concluded that because GOs and concept maps are more spatial than outlines and texts, they are encoded in memory in a more spatial format than are the more linear displays. Additional support for this claim has recently been reported by Robinson, Robinson, and Katayama (submitted).

If one assumes that students search their mental representations when attempting to answer questions about information presented in the text, then the more efficiently organized the mental representation, the more likely the student will be able to retrieve the necessary information. Although no studies have directly examined exactly how students mentally retrieve information (which would be very difficult to do), there have been recent studies where students retrieve information from external (on paper) representations to answer comprehension questions. Robinson and Skinner (1996) found that when students searched GOs, they found information needed to answers questions faster than when they searched outlines or texts. These results provide additional evidence that GOs are computationally more efficient than outlines or texts, facilitating both local (searching for concept facts) and global (searching for concept relations and patterns among concept attributes) search tasks. Thus, one possible explanation for why GOs facilitate learning of concept relations is that they are mentally stored in an efficient, spatial format that can be easily searched for information, sort of like a library that is neatly organized as opposed to one where books are stacked in piles.

Although the practice of including GOs in textbooks and study guides has been increasing, most of the research studies that have investigated their instructional potential have failed to examine them in authentic learning environments (see Robinson, in press, for a review). "Typically studies have used short, poorly organized text, single GOs, and immediate tests measuring only factual knowledge" (Robinson & Kiewra, 1995, p. 455). Robinson and Kiewra (1995) attempted to address these weaknesses by investigating the relative effectiveness of multiple adjunct displays (outlines and GOs) in facilitating students' learning of concept facts, relations, and transfer when studied in conjunction with a chapter-length, well-organized text. To encourage students to become more involved with the content of the text, instructional directives were inserted in the text that directed the students to view the adjunct displays.

In Experiment 1, students studied either the text alone, the text plus outlines, or the text plus GOs for one hour and then were tested either immediately or two days later. Two noteworthy findings were observed. First, students who studied GOs learned more coordinate concept relations than the outline and text only groups, and expressed more of them in a contrastive manner than the outline group. This finding demonstrated that GOs also facilitate learning of coordinate concept relations for longer text. Second, on the application test which measured transfer, for students who studied only the text, there was a decrease in performance from immediate to delayed testing, whereas the GO group experienced no decrease. This finding supported the delay hypothesis (Andre, 1990), which suggests that adjunct aids' facilitative effects are more resistant to a delay. Moreover, because a GO advantage was observed across both immediate and delayed testing conditions, these results suggested that for chapter-length text and multiple GOs, computational efficiency of the GOs is not detrimental to long-term learning, as suggested by Robinson and Schraw (1994).

Although some new advantages to studying GOs were found, GOs were not shown to be more effective for either learning hierarchical relations (text structure) or applying knowledge to solve problems (transfer). Robinson and Kiewra (1995) speculated that students in the GO group may not have had enough time to take full advantage of the GOs. To test this hypothesis, in Experiment 2, students were given one hour to study and then two days later had an additional 15 minutes to review before being tested. It was hypothesized that this study sequence would avoid problems associated with fatigue (i.e., subject tolerance) and be more similar to what students actually do. This time the GO group outperformed both the text only and outline groups on the hierarchical relations and application tests. Robinson and Kiewra concluded that the appearance of these differences in Experiment 2 could be attributed to students receiving adequate time to study their materials, based on the fact that only 8% of the students in the GO and outline groups indicated that they did not have adequate time to study the displays as compared to 40% in Experiment 1. They failed to consider, however, the possibility that this appearance of differences may have simply been due to delaying review, rather than increasing study time. It is this issue that motivated the present study.

Delayed Review is better than Immediate Review

The study sequence employed by Robinson and Kiewra (1995) in Experiment 2 involved interspersing two exposures to the same material with a delay. In effect, they were using a distributed practice sequence rather than the massed practice sequence used in Experiment 1 where the two exposures were not separated by a delay. Distributed practice has long been linked to the spacing effect - a learning phenomenon where, given the same amount of time, persons who intersperse study sessions with delays learn better than those whose study sessions are massed together with no delays (see Dempster & Ferris, 1990, for a more detailed account).

Although many factors may be involved in producing the spacing effect (Anderson, 1990), two explanations have been identified to date. The first explains how forgetting can be beneficial for long-term retention. The "deactivation hypothesis" (Krug, Davis, & Glover, 1990) states that when information is first encountered, full processing occurs, the information becomes "active" in memory, and then soon begins to "deactivate". If the same information is encountered a second time while it is still active in memory, only partial processing or activation will occur. If, however, the information is encountered a second time after it has deactivated, full processing will again occur, strengthening the memory structure more than if only partial processing had occurred. Stronger memory structures are more likely to be retrieved than weak ones (Anderson, 1990).

A second possible explanation for the spacing effect is based on the idea that additional information in the learning environment (e.g., surroundings, lighting, temperature, etc.) is encoded and associated in memory with the target information (i.e., what is supposed to be learned). Because contextual elements are associated with the target information in memory, they may serve as retrieval cues. If the test context overlaps with the study context, additional retrieval cues will be available and test performance will increase. Godden and Baddeley (1975) demonstrated this fact in a rather unique way. Divers learned a list of words either on land or under water and then attempted to recall the words either on land or under water. Those whose test environment was the same as their learning environment had the best recall performance. When information is studied on different occasions, each occasion involves encoding different contextual cues. When study occasions are distributed over time, the study contexts will differ more from each other than if the study occasions are massed together. The more two study contexts differ, the more likely one of the contexts will overlap with the test context. Different contexts mean more contextual cues and increase the probability that a particular cue may be present at the time of retrieval (Anderson, 1990).

Thirty-six years ago, Underwood (1961) concluded that the spacing effect is unimpressive because it is restricted to very specific conditions and the effect itself is small. In studies conducted since then, however, the spacing effect has been found to be a robust and powerful phenomenon that generalizes to textbook material (Anderson, 1990). Unfortunately, evidence suggests that educators may still believe the earlier conclusions of Underwood. Zechmeister and Shaughnessy (1980) found that many people believe that massed review is better than spaced review. Dempster and Ferris (1990) even noted that one influential educator (Hunter, 1983) has advised against spaced review. Dempster and Ferris concluded that the full potential of the spacing effect has not been realized mainly because reviews are not always popular among teachers. In the present study, we wanted to see if the previously observed advantages of studying graphic organizers in addition to chapter-length text are restricted to study sequences that employ delayed, rather than immediate, review.

Experiment 1

Experiment 1 was to designed to investigate whether the facilitative advantages of GOs over outlines and text-only for learning hierarchical concept relations and transfer observed by Robinson and Kiewra (1995, second experiment) may have been due to delayed review rather than increased study time. Our study was very similar to their experiment, except that we directly compared immediate and delayed review conditions. Most importantly, we gave students in both the immediate and delayed review groups the same amount of total study time to examine the effects of review occasion absent any increases in study time. Finally, because we were mainly interested in finding differences between the GO and outline groups, students were administered only the hierarchical relations and application tests. Robinson and Kiewra found no differences between outlines and GOs on the facts tests, and the same advantage for the GO group over

the outline group on the coordinate concept relations measure for both immediate and delayed review conditions.

Method

Participants and Design

Eighty-nine students enrolled in an undergraduate educational psychology course at a state university in the South were assigned randomly to one cell of a 3 by 2 design (cell sizes are displayed in Table 1). The first factor was study materials (text-only, text-plus-outlines, or text-plus-GOs), and the second factor was review occasion (immediate or 2-day delay). Testing took place in groups of about 30 students, mixed with respect to study materials conditions, in a typical university classroom.

Materials

The materials were identical to those used by Robinson and Kiewra (1995).

Text. A 6500-word text (12 pages, single-spaced) on abnormal behavior was used. Most of the material was taken from an undergraduate psychology textbook (Davidoff, 1976), with a section on psychopathic behavior taken from a similar textbook (Rubin & McNeil, 1981). Two versions of the text were used, one for the text-only group and one for the two adjunct displays groups. The latter version included seven additional sentences, each placed at the end of sections, that directed the reader to view one of the seven displays.

Adjunct displays. Seven adjunct displays, in both GO (six matrices and one tree diagram) and outline format, were used. Examples of both types of displays are shown in Figures 1 and 2.

Tests. Two tests were used. The hierarchical relations test contained 21 cued-recall items requiring knowledge of text structure. It was printed over four pages, with items arranged so they would not provide clues to other items on the same page or on succeeding pages. The application test contained 15 matching items that required identification of disorders, given novel examples of symptoms. Names of all 16 disorders mentioned in the text appeared in an alphabetical list, and students were instructed that some names may have been used more than once or not at all. Examples of each test item appear below.

Hierarchical Relations
List the four types of schizophrenia described in the text.

Application
Karen spent most of her day hanging out at the local beauty parlor. The other women were becoming tired of hearing her outrageous stories. For example, Karen once told them that she, not Queen Elizabeth, was the rightful heiress to the British throne and that she had been denied her privileges by the CIA. At another time she insisted that it was she, and not Jonas Salk, that had developed the polio vaccine.

Procedure

Sessions were conducted in a single 80-minute period for the immediate groups and a 50-minute period combined with a 30-minute period 2 days later for the delayed groups. First, all students were randomly assigned to either the immediate or the delayed conditions. Students in the immediate condition were excused and told to return two days later. Students in the delayed condition were given envelopes containing study materials and wrote their names on labels affixed to the envelopes. The envelopes were arranged in a systematic order to ensure approximately equal numbers of participants in each study materials condition. Students were told they had 50 minutes to read and study their materials. After the 50

minutes had expired, students placed their materials back into the envelopes, were told not to discuss the experiment, and were excused.

Two days later, the students in the immediate condition returned and were given envelopes containing the study materials. They were also told that they had 50 minutes to read and study the materials. After the 50 minutes had expired, students placed their materials back into the envelopes and remained seated at their desks. Students in the delayed condition entered the classroom and were seated. The experimenter read their names from the labeled envelopes and gave them their study materials. Next, all students were given 10 minutes to review their materials. After the 10 minutes had expired, all study materials were collected from the students. The experimenter distributed a series of test sheets (hierarchical relations) which students completed one at a time, placing them in their envelopes, so that they could not return to complete an earlier test based upon knowledge gained from subsequent test sheets. This procedure lasted about 10 minutes. Students then completed the application test in about 10 minutes and placed it in their envelopes. Students in the delayed condition were told to remove their labels so that performances could not be associated with names.

Scoring

All tests were scored by (the second author) without knowledge of group affiliation (tests were previously coded) in accordance with predetermined keys, with a maximum score equal to the number of items.

Results

Table 1 presents means and standard deviations for scores on the two tests. All statistical tests were conducted at the alpha = .05 level of significance. For each test, a 3 (study materials) by 2 (review occasion) factorial analysis of variance (ANOVA) was conducted.

Hierarchical Relations

The main effects of study materials and review were not significant, $F(2, 82) = 1.85$ and $F(1, 82) = .29$, respectively. The interaction effect of study materials by review, however, was significant, $F(2, 82) = 3.41$, $MSE = 15.21$, $p = .038$ (see Figure 3). Once again, no tests of simple effects comparing the three study materials groups within each review occasion condition were significant. However, simple effects tests comparing the review occasion groups within each study materials condition indicated that for both the text-only [$F(1, 82) = 1.71$, $p = .19$] and the outline conditions [$F(1, 82) = .00$, $p = .96$] the effect of review was not significant, whereas for the graphic organizer condition the delayed review group scored higher than the immediate review group, [$F(1, 82) = 5.48$, $p = .022$].

Application

The main effects of study materials and review were not significant, $F(2, 82) = .24$ and $F(1, 82) = .36$, respectively. The interaction effect of study materials by review occasion, however, was significant, $F(2, 82) = 3.93$, $MSE = 8.10$, $p = .024$ (see Figure 4). Tests of simple effects were then conducted to see if the three study materials groups differed within each review occasion condition. None of these simple effects were significant, so a second set of simple effects tests were conducted to see if the two review conditions differed within each study materials condition. For both the text-only [$F(1, 82) = 2.33$, $p = .13$] and the outline conditions [$F(1, 82) = .04$, $p = .85$] the effect of review was not significant. However, for the graphic organizer condition the delayed review group scored higher than the immediate review group, [$F(1, 82) = 5.94$, $p = .017$].

Discussion

The present study investigated whether facilitative effects of delaying review for learning text structure and transfer depend on the type of study materials reviewed. Undergraduates studied either a chapter-length text, the text plus a set of GOs, or the text plus a set of outlines. Students were given 50

minutes to study their materials, and then either immediately after or two days later they studied for an additional ten minutes. Students were then tested over knowledge of text structure and transfer. Results indicated that for those who studied text plus GOs, those who delayed review performed better than those who immediately reviewed. For students who studied either text-only or text plus outlines, performances did not differ among the immediate and delayed review groups. These results are consistent with those obtained by Robinson and Kiewra (1995) in terms of differences between Experiments 1 and 2. But more importantly, because both review groups were given the same amount of study time, the results of the present study suggest that GOs' facilitative effects for learning text structure and transfer depend on delaying review, and not on additional study time as suggested by Robinson and Kiewra.

Why does delaying review facilitate learning from GOs, but not outlines or text? One reason may have to do with the nature of the learning task. Mumford, Costanza, Baughman, Threlfall, and Fleishman (1994) had students perform spatial visualization and perceptual speed tasks. Students then practiced a complex skill by either massing or distributing their practice. Perceptual speed facilitated performance for those who massed their practice, whereas spatial visualization facilitated performance for those who distributed their practice. Mumford et al. concluded that distributed practice facilitates spatial visualization, whereas massed practice facilitates associational learning.

Robinson, Katayama, and Robinson (in preparation) investigated the possibility that information contained in spatial displays, such as GOs and concept maps, may be represented in memory in a different format than that information contained in linear displays, such as outlines and texts. In one of the experiments, students viewed one of the four types of displays and then viewed a either a spatial configuration of dots or a verbal list of digits. They then answered a comprehension question about the display and attempted to identify either the dots or digits they had previously seen. Viewing dots inhibited comprehension performance for GOs and concept maps, whereas viewing digits inhibited comprehension performance for outlines or texts. Robinson et al. (submitted) concluded that retrieving information that is encoded as a result of viewing spatial displays involves the use of spatial working memory. Information encoded as a results of viewing linear displays, however, involves the use of verbal working memory. This evidence, when combined with the findings of Mumford et al. (1994), suggests that because studying GOs appears to be a more spatial, rather than associational task, distributed practice is beneficial. However, because studying outlines and texts is not a spatial task, and in fact may be a more associational task, there is no advantage for distributing practice.

Based on the deactivation hypothesis (Krug et al., 1990), we offer the following explanation to account for the present findings. When students study only the text or outlines, they attempt to simply associate facts with concept names and then rehearse those associations. When review is immediate, they have just completed reading the text and the association strategy works well because memory for the associations is still active. The active memory of these associations is then used to answer questions about more complex associations like hierarchical concept relations. The point here is that because memory for the individual associations is still active, students can be moderately successful performing more complex retrieval tasks. However, when practice is distributed, the associations that were learned on the initial study session have deactivated and students must spend the short, 10-minute study period attempting to reactivate each of the several previously learned associations. Although the results of the present study did not indicate a statistically significant advantage for immediate review over delayed review, students who studied only the text had their best performances when study was massed.

When students study GOs, they attempt to visualize the GO and learn the overall structure of the material. They do not concentrate on specific associations, but rather they focus on hierarchical and coordinate concept relations. When review is immediate, students' memory for the text is still active and they are not able to perform the deep, elaborative processing required to learn the concept relations. This is because the development of knowledge structures requires that memory for individual associations (concept facts) must deactivate so more complex relations can be learned (Mumford et al., 1994). When review is delayed, however, students' memory for associations has deactivated and they can focus on learning the overall structure of the material.

Because most GO research has used short texts and tested only knowledge of facts immediately after study, the combined benefits of GOs and delayed review have not been previously shown. The main advantage to studying GOs may lie in the type of processing they encourage. When students are given text or a text plus outlines, they may attempt to associate concept names and facts rather than attempting to

understand the "big picture". When students are given GOs, however, they may attempt to learn the structure rather than the facts. The implications of the present study are important because no one has considered how GOs should be provided to students. Moore and Readance (1980) conducted a meta-analysis of studies investigating GOs and concluded that GOs are most effective when presented after the text has been read, rather than before. We recommend that GOs be presented perhaps a few days after the text has been read or at least until students' memory for the text has deactivated. With a delayed review, students would be able to focus on relations communicated by the GOs instead of trying to remember the surface structure of the text.

Although the present study addressed a possible confounding variable (different study time) in the Robinson and Kiewra (1995) study, it, too, has a few limitations. First we could not be sure that students were spending equal amounts of time studying the GOs and outlines. Some students finished reading the text early and thus had more time to study the adjunct displays. These differences were controlled somewhat, but not completely, by random assignment. Second, providing students with materials may be a good idea but most would agree that an even better idea would be to have students construct GO notes themselves. Currently, we are developing a study to investigate the effects of having students learn to construct GOs on their own and then study them after a delay. Although this practice may not be more authentic than simply providing notes, we feel that is a potentially more effective learning activity.

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Table 1

Means (and Standard Deviations) for Percent Correct Scores by Group in Experiment 1.

			Study Materials		
Review	Test		Text-only	Outline	Graphic Organizer
Immediate	Hierarchical Relations		26.52 (16.38)	31.43 (21.14)	19.67 (13.90)
	Application		48.07 (26.07)	43.13 (17.07)	32.00 (15.13)
		n	14	15	15
Delayed	Hierarchical Relations		17.33 (13.14)	31.10 (19.19)	35.57 (24.52)
	Application		37.13 (15.87)	44.47 (17.07)	48.87 (20.40)
		n	14	15	15

Table 2

Means (and Standard Deviations) for Percent Correct Scores by Group in Experiment 2.

			Study Materials		
Review	Test		Text-only	Outline	Graphic Organizer
Immediate	Hierarchical Relations		41.67 (33.33)	61.42 (30.50)	66.25 (22.83)
	Application		70.50 (21.14)	74.74 (26.32)	68.95 (16.96)
		n	20	19	19
Delayed	Hierarchical Relations		44.83 (33.75)	57.42 (30.00)	70.83 (23.42)
	Application		61.88 (26.64)	70.00 (20.58)	85.00 (20.07)
		n	16	18	18